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09/846,980	04/30/2001	Stephen A. Stockman	M-9635 US	3906

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Brian D. Ogonowsky
SKJERVEN MORRILL MacPHERSON LLP
Suite 700
25 Metro Drive
San Jose, CA 95110-1349

EXAMINER	
SONG, MATTHEW J	

ART UNIT	PAPER NUMBER
1765	3

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Please find below and/or attached an Office communication concerning this application or proceeding.

TD-3

Office Action Summary	Application No. 09/846,980	Applicant(s) STOCKMAN ET AL.	
	Examiner Matthew J Song	Art Unit 1765	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *4/30/2001* .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☐ Claim(s) _____ is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-30* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *30 April 2001* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☒ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 2 .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other:

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claims 1-5, 12, 14-30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319).

Bour et al. teaches a carrier gas of H_2 is introduced with reaction gases NH_3 and TMGa and impurity gas Cp_2Mg to a reactor to form a p-type GaN layer at a temperature of 900°C (col 6, 20-26) After formation of the p-type nitride layer the reactant gases are switched out of the reactor and a gas which prevents the decomposition of the III-V layer at such high growth temperatures, NH_3 is added (col 5, ln 60-65 and col 6, ln 31-35). Bour et al also teaches a reactor is cooled down to a temperature where surface decomposition of as-grown p-type GaN layer will not further occur, where upon attainment of the this temperature, the preventer gas, NH_3, is switched out of the reactor and the remaining cool down occurs in molecular N and acceptor activation is preformed either as the reactor is further cooled or maintained at a temperature of 600°C for 20-40 minutes and during the cool down of the reactor a flow of molecular N, N_2, is maintained in the reactor. (col 6, ln 40-65). Bour et al also teaches the anneal process is a quasi-in-situ anneal, where the reactor is brought to room temperature prior to annealing (col 2, ln 32-45) and that ex-situ post-growth anneals have become a common procedure for laser diode processing (col 2, ln 60-64). Bour et al also teaches acceptor activation is the process of atomic

H weakly bonded to Mg or Zn dopant atoms are broken by thermal annealing over a period of time (col 6, 7-15) Bour et al also teaches a device which comprises a sapphire substrate upon which is grown a n-type GaN, doped with Si followed by the growth of an active region and is followed by a p-type GaN layer doped with Mg followed by the growth of a cap layer comprising n-type GaN doped with Si (col 8, ln 46-55) Bour et al also teaches that after growth is complete and the reactor cooldown has been accomplished, the n-type cap layer may be removed by etching and the device processed into an operable laser, this reads on applicant's limitation of forming a light emitting diode.

Bour et al does not teach the causing of the acceptor doped layer to a p-type layer have a conductivity and a hole density between 3×10^{15} cm^{-3} and 1×10^{18} cm^{-3} after said cool down process.

In a method of growing p-type gallium nitride, Koike et al. teaches three p-layers of Mg-doped $Al_{x1}Ga_{1-x1}N$ forms a p-layer (61) which acts as a clad layer having a hole concentrations of $5 \times 10^{17}/cm^3$, $5 \times 10^{17}/cm^3$ and $2 \times 10^{17}/cm^3$ and an Mg concentrations of $1 \times 10^{20}/cm^3$, $1 \times 10^{20}/cm^3$ and $2 \times 10^{20}/cm^3$, respectively (col 3, 50-65). Koike also teaches electron rays were uniformly irradiated into the p-layer using a reflective electron beam, where this irradiation changed the p-layer into a p-type conductive semiconductor with a hole concentration of $5 \times 10^{17}/cm^3$, $5 \times 10^{17}/cm^3$ and $2 \times 10^{17}/cm^3$ and a resistivity of 0.5 ohm-cm, 0.8 ohm-cm and 1.5 ohm-cm, respectively (col 5, ln 14-26). Koike et al also teaches forming metal electrode, such as nickel or aluminum, are formed on semiconductor devices utilizing GaN group compounds such as AlGaInN after the semiconductor surface is cleaned by wet chemical etching, utilizing a wet chemical etchant such as buffered hydrogen fluoride (col 1, ln 15-30).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Bour with Koike's electron beam irradiation because it would have produced p-type conductive semiconductors with low resistivities.

Referring to claim 2 and 3, the combination of Bour and Koike teaches a step (32) where reactant gases are switched out of the reactor and a flow of N_2 is maintained during the cooldown of the reactor. This reads on applicant's limitation of preventing additional hydrogen from diffusing into said acceptor-doped layer during said cooling process. Also this reads on applicant's limitation of removing hydrogen from said chamber during cool-down process and preventing hydrogen from entering.

Referring to claim 4, the combination of Bour and Koike teach a cap layer comprising n-type GaN doped with Si, this reads on applicant's limitation of preventing additional hydrogen from diffusing into said acceptor-layer comprising form a n-type semiconductor layer over said acceptor-doped layer prior to said cool-down process.

Referring to claim 5, the combination of Bour and Koike teach electron beam irradiation of said p-type layer to produce conductive semiconductors with low resistivities with hole densities of greater than $1 \times 10^{17}/cm^3$. This reads on applicant's limitation of treating a surface of said acceptor-doped layer to increase hole density to be greater than 3×10^{15} cm^{-3}.

Referring to claim 13, electron rays were uniformly irradiated into the p-layer using a reflective electron beam, this reads on applicant's limitation of exposing said surface to electromagnetic radiation.

Referring to claim 14, the combination of Bour and Koike does not teach growing an acceptor doped layer results in acceptor impurities in said acceptor-doped layer having greater

than 90% passivation prior to said cool down process. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Bour and Koike by attempting to optimize same by routine experimentation.

Referring to claim 15 and 16, the combination of Bour and Koike teach three p-layers of Mg-doped $Al_{x1}Ga_{1-x1}N$ p-layer (61) which acts as a clad layer having a hole concentrations of 5 x $10^{17}/cm^3$, 5 x $10^{17}/cm^3$ and 2 x $10^{17}/cm^3$ and an Mg concentrations of 1 x $10^{20}/cm^3$, 1 x $10^{20}/cm^3$ and 2 x $10^{20}/cm^3$. This reads on applicant's limitation of a hole density greater than 3 x 10^{16} cm^{-3} and having a density of acceptor impurities greater than 5 x 10^{18} cm^{-3}.

Referring to claim 18, the combination of Bour and Koike does not teach the annealing is carried out at a temperature below 400°C. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Bour and Koike by attempting to optimize same by routine experimentation.

Referring to claim 19, the combination of Bour and Koike teach all of the limitations of claim 19, except an ex-situ anneal. The combination of Bour and Koike teach ex-situ post-growth anneals have become a common procedure for laser diode processing. It would have been obvious to a person of ordinary skill in the art at the time of the invention to perform the annealing process ex-situ because it allow the reaction chamber to be used to for the growth of more p-type GaN.

Referring to claim 20, the combination of Bour and Koike teach the anneal process is a quasi-in-situ anneal where the reactor is brought to room temperature prior to annealing, this reads on applicant's limitation of annealing is carried out after said cool-down process prior to any further processing of said p-type layer.

Referring to claim 21, the combination of Bour and Koike teach a device (40) processed into an operable laser, this reads on applicant's limitation of forming a light emitting diode.

Referring to claim 22, the combination of Bour and Koike teach a sapphire substrate upon which is grown a n-type GaN, doped with Si followed by the growth of an active region and is followed by a p-type GaN layer doped with Mg.

Referring to claim 23, the combination of Bour et al and Koike et al. teaches three p-layers of Mg-doped $Al_{x1}Ga_{1-x1}N$ forms a p-layer (61).

Referring to claim 25, the combination of Bour et al and Koike et al. does not teach annealing is carried out to remove said hydrogen from said p-type layer as well as anneal or alloy a p-type ohmic contact.

3. Claims 6, 9 and 11 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319) as applied to claim 1 above, and further in view of Takatani (US 6,100,174).

The combination of Bour et al and Koike et al teach all of the limitations of claim 6, except chemically etching said surface.

In a method of producing GaN group compound semiconductors, Takatani teaches a p-GaN layer epitaxially grown on a sapphire substrate, with about 10^{19} cm^{-3} of Mg added thereto for providing a carrier density of about 1.5×10^{17} cm^{-3}, where carrier density reads on applicant's term of hole density. Takatani also teaches subjecting the surface of the p-GaN layer to ultrasonic cleaning in acetone and ethanol, thereby removing the oil present thereon and then immersing in an etchant containing HCl and deionized water for about 3 minutes, thereby

removing the adsorbed oxide and then the substrate is immersed in an etchant containing HF and deionized water for about 3 minutes thereby removing impurities adhering to the surface, this reads on applicant's limitation of chemically etching. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the invention taught by the combination of Bour and Koike with Takatani's etching because it would have removed impurities and adsorbed oxygen from the substrate.

Referring to claim 9, the combination of Bour et al and Koike et al teach all of the limitations of claim 9, except chemically cleaning said surface.

Takantani teaches immersing a p-GaN substrate in an etchant containing HCl and deionized water for about 3 minutes, thereby removing the adsorbed oxide and then the substrate is immersed in an etchant containing HF and deionized water for about 3 minutes thereby removing impurities adhereing to the surface. This reads on applicant's limitation of chemically cleaning said surface.

Referring to claim 11, the combination of Bour et al and Koike et al teach all of the limitations of claim 11, except ultrasonically cleaning said surface.

. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the invention taught by the combination of Bour and Koike with Takatani's ultrasonic cleaning because it would have removed the oil present on the surface of the substrate.

4. Claim 10 is rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319) and Takatani (US 6,100,174) as applied to claim 9 above, and further in view of Peng et al. (US 5,895,223).

The combination of Bour et al, Koike et al and Takatani teach all of the limitations of claim 10, expect the cleaning of said surface comprises cleaning in a solution of KOH, NaOH or NH_4OH.

In a method of etching nitride, Peng et al teaches dipping a nitride chip in an electrolysis liquid and emitting a UV light with a wavelength of 254 nm to illuminate the nitride chip (col 3, ln 40-46), where the electrolysis liquid can be one of KOH as the nitride chip is GaN. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Bour et al, Koike et al and Takatani with Peng's because the etching method of Peng offers a finer roughness for an etching surface (col 4, ln 20-24).

5. Claim 13 is rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319) as applied to claim 5 above, and further in view of Peng et al. (US 5,895,223).

The combination of Bour et al and Koike et al teach all of the limitations of claim 13, expect exposing said surface to electromagnetic radiation.

In a method of etching nitride, Peng et al teaches dipping a nitride chip in an electrolysis liquid and emitting a UV light with a wavelength of 254 nm to illuminate the nitride chip (col 3, ln 40-46), this reads on applicant's limitation of exposing to electromagnetic radiation, where the electrolysis liquid can be one of KOH as the nitride chip is GaN. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Bour et al, Koike et al and Takatani with Peng's because the UV light would illuminate the nitride chip.

6. Claim 7 and 8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bour et al. (US 5,926,726) in view of Koike et al. (US 5,811,319) as applied to claim 5 above, and further in view of Nitta et al (US 5,789,265).

The combination of Bour et al and Koike et al teach all of the limitations of claim 7, expect plasma etching said surface.

In a method of manufacturing a blue light emitting diode, Nitta et al. teaches a dry etching method for GaN based semiconductor compounds can be achieved by the plasma etching using BCl_3 and Cl_2, where said GaN based semiconductor comprises p-type $In_xGa_{1-x}N$ (col 4, ln 41-55). It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Bour et al and Koike et al with Nitta et al because etching rate can be increased and productivity enhanced.

Referring to claim 8, Nitta et al. teaches a dry etching method for GaN based semiconductor compounds, this reads on applicant's limitation of plasma cleaning said surface.

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J Song whose telephone number is 703-305-4953.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Benjamin L Utech can be reached on 703-308-3868. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9310 for regular communications and 703-872-9311 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0661.

mjs
April 22, 2002

BENJAMIN L. UTECH
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 1700